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IGNITION AND CHARRING TEMPERATURES OF WOOD

By

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A review of the technical literature reveals but a limited amount of data concerning minimum temperatures required to produce charring or ignition of wood. Results obtained by different investigators for ignition temperatures show wide discrepancies. As Brown (1)[2] has indicated, the different values reported may be due to the specific test conditions associated with the methods employed, and also to the different interpretations among investigators as to what constitutes "ignition temperature."

Available published reports (1), (2), (4), (5), and (7) on investigations of the ignition of wood usually deal with temperatures, size of material, and rate of air supply in the range that will cause ignition within a few minutes. No available publications relate to long exposures at the lower ranges of elevated temperature to which wood may often be subjected in actual use conditions,

The purpose of this report is to indicate the importance of time in the effects of heat upon wood rather than to present specific values for ignition temperatures or to recommend methods for determining such temperatures.

A previous investigation by R. E. Prince (7) demonstrated clearly that what he termed the "ignition temperature" for wood does not have a fixed value but is greatly influenced by the duration of exposure. In that work, oven-dry wood specimens 1-1/4 by 1-1/4 by 4 inches were exposed continuously to different temperatures maintained constant in an electrically heated apparatus. Record was made of the time that the specimens had to be kept at a specified temperature before the gases issuing from the specimens could be ignited by a pilot flame located about one-half inch above the test sample. The results reported for specimens of different species are shown in table 1.

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[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[2] Numbers in parentheses refer to literature cited at the end of this report.

The data are somewhat erratic, especially at the lower temperatures, and they fail to show a consistent relation of ignition time to the specific gravity of the wood. It is probable that further, more comprehensive, testing may remove some of the apparent inconsistencies. Earlier studies, in which exposure was made at gradually increasing temperatures, showed that, as a general rule, a species of low specific gravity could be expected to ignite more readily than one of high specific gravity, provided that the specimens did not vary greatly in their content of resin or other extractive materials that would influence their behavior. It was also shown that ignition might either be hastened by the presence of flammable oils or resins, or be retarded by the presence of other extractives. Aside from these exceptional cases, specific gravity of the test piece was considered more important than species characteristics in influencing ignition when the size of the specimen, moisture content, and conditions of fire exposure were identical.

Some exploratory tests at the Forest Products Laboratory conducted more recently at a lower range of elevated temperature have demonstrated further the importance of time on the behavior of wood heated continuously. In these tests, small kiln-dried, hard maple motor wedges, about 1/8 by 1/4 by 3 inches which were to be used in a special motor for hot-air ducts, were subjected to temperatures ranging from 107° to 150° C. for various extended periods in electrically controlled drying ovens.

With prolonged exposure at all of the temperatures used there was a gradual darkening of the wood, accompanied by loss of weight and shrinkage in the transverse dimensions of the specimen. Chemical destruction of the specimens, as indicated by their loss of weight, was not associated with any one critical temperature. Instead, at each temperature of exposure, the specimens lost weight at a rather regular rate, and the rate became faster as the temperature was raised.

Samples which had been exposed to 107° C. for 1,050 days assumed a light chocolate shade. Those exposed to 120° C. for 1,235 days became appreciably embrittled, were of a dark chocolate color, and when moistened were strongly acid to litmus paper. Those exposed to 140° and 150° C. had the appearance and friability of charcoal even before they had lost 65 percent of their original air-dry weight at 6 to 8 percent moisture content, but none was ignited during its exposure.

A summary of weight losses and transverse shrinkage for different heating periods is given in table 2.

Although comparable data are unavailable, experience leads to the belief that other species would perform in much the same general manner as the maple used in these tests.

The fact that ignition did not occur at any time during this series of tests is no guarantee that it could not have done so if conditions more favorable for combustion had prevailed. In the lower range of temperature values, decomposition proceeded so slowly that the gaseous products evolved were dissipated in the surrounding air. In a confined space, however, the opportunity for escape of the

gases and the heat accompanying oxidation would be lessened, and the danger of developing spontaneous ignition would be increased. This may account for the fires that have been reported to have started in wood in direct contact with low-pressure steam pipes or in wood heated at temperatures below that where the exothermic reaction normally becomes a factor (9). There are also indications from experience with wood in dry kilns, steam tunnels, and other places that long continued intermittent heating and exposure to damp conditions accelerate the decomposition of wood.

Little detailed information is available on the amounts and composition of the products formed at the temperatures and exposures described in table 2. Klar (3) reported that upon heating wood between 150° and 200° C., the composition in percent by volume of noncondensable gases is 68 percent carbon dioxide, 30.5 percent carbon monoxide, and 2 percent hydrocarbons. Murphy's investigation (6) of the thermal decomposition of paper below ignition temperatures also shows the evolution of gases to be a function of time and temperature.

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Table 1.--Effect of temperature and time of exposure upon the ignition of wood

Temperature of exposure	Duration of exposure before ignition[1]								
	Longleaf	Red oak	Tamarack	Western larch	Noble fir	Eastern hemlock	Redwood	Sitka spruce	Basswood
°C.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.
180	14.3	20.0	29.9	30.8	......	....	28.5	40.0	......
200	11.8	13.3	14.5	25.0	......	13.3	18.5	19.6	14.5
225	8.7	8.1	9.0	17.0	15.8	7.2	10.4	8.3	9.6
250	6.0	4.7	6.0	9.5	9.3	4.0	6.0	5.3	6.0
300	2.3	1.6	2.3	3.5	2.3	2.2	1.9	2.1	1.6
350	1.4	1.2	.8	1.5	1.2	1.2	.8	1.0	1.2
430	.5	.5	.5	.5	.3	.3	.3	.3	.3
Reported average specific gravity of specimens	.70	.68	.60	.48	.46	.38	.35	.34	.31

[1]In general, the values shown represent the average of two tests.

Table 2.--Loss in weight and transverse shrinkage of hard maple specimens during oven heating

Duration of heating				Loss of weight[1]	Average transverse shrinkage (approximate)
at 107° C.	at 120° C.	at 140° C.	at 150° C.		
Days	Days	Days	Days	Percent	Percent
1,050	425	22	16	15	5.0
....	870	58	35	25	9.5
....	1,235	117	58	35	14.0
....	....	178	88	45	19.5
....	....	320	165	65	32.0

[1]Weight losses include 6 to 8 percent moisture that was in the wood at the start of the heating period.

Report No. 1464

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ATTESTATION

Je soussigné, Laurençot Jean né le 20.02.1937 à 25640 Roulans France, demeurant 14B, rue de la Gare, à 25720 Beure France, certifie l'authenticité des informations suivantes qui traitent des risques qui peuvent être causés par des installations de traitement du bois à haute température, insuffisamment sécurisées au niveau du contrôle et du maintien de l'ambiance neutre dans l'enceinte de traitement.

Si le bois traité thermiquement à haute température présente des avantages incontestables en raison de sa bonne résistance à la putrescibilité et sa faible variation dimensionnelle ; les moyens ou fours à même de permettre d'effectuer un traitement jusqu'à 230°C nécessitent, tant pour leur conception que pour leur réalisation et leur utilisation, une attention très particulière ainsi que des moyens extrêmement spécifiques et fiables.

En effet, lorsque l'on sait que certaines essences de bois s'enflamment à des températures inférieures à 200°C, on comprendra aisément que porter un tel matériau à 230°C entraînera la conception d'un outil, ou four, très spécifique, comportant, outre une enceinte de traitement étanche, un ensemble de moyens aptes à permettre de créer et maintenir une ambiance neutre sécurisée nécessaire et indispensable pour éviter les inflammations de la charge de bois ainsi que les risques d'explosion.

On connait les accidents survenus, lors de la montée à des températures supérieures à 200°C sur diverses installations qui ne comportent pas les moyens indispensables pour ce faire.

Sans préciser les coordonnées, car ce n'est pas l'objet de ce document, je peux donner quelques exemples qui confirmeront la nécessité de considérer les informations précédentes avec la plus rigoureuse attention.

- 2006 dans le Nord-Est de la France un four récemment installé, devant permettre de pratiquer un traitement jusqu'à 230°C, est partiellement détruit par un incendie. La charge de $10m^3$ de bois est détruite.
  Cause : défaut d'étanchéité, pénétration d'oxygène dans le four à haute température + défaut de fonctionnement des sécurités. Ce four est remis en état et en service quelques mois plus tard.

- 2009 Ce même four est à nouveau partiellement détruit par un nouvel incendie, même causes, semble t-il, qu'en 2006. Il a été remis en état et service fin 2009

- Entre 1998 et 2008 deux fours d'une autre fabrication sont détruits par des explosions ou incendies.

- D'autres types de four destinés au traitement du bois à haute température, qui ne disposent pas des moyens nécessaires pour éviter les risques d'incendie ou d'explosion, sont limités aux traitements ne dépassant pas 170 à 190 °C.

Fait à 25720 Beure, France, le 10 mars 2010.

Jean Laurençot

CERTIFICATE

I, the undersigned, Jean Laurençot, born February 20, 1937, at 25640 Roulans, France, residing at 14B, rue de la Gare, at 25720 Beure, France, certify the authenticity of the following information which deals with the risks which can be caused by installations for the treatment of wood at high temperature, insufficiently protected in the control and maintenance of a neutral environment within the treatment enclosure.

If wood heat treated at high temperature presents undeniable advantages because of its good resistance to putrescibility and its low dimensional variation, the means or furnaces which make it possible to carry out a treatment up to 230°C require for their design, as well as for their realization and their use, very detailed attention as well as extremely specific and reliable means.

Indeed, when it is known that certain wood turpentines ignite at temperatures lower than 200°C, it is easily understood that to carry such a material to 230°C will involve the very specific design of a tool, or furnace, comprising, in addition to a tight treatment enclosure, a set of means capable of creating and maintaining the protected, neutral environment necessary and essential to avoid ignitions of the load of wood as well as the risks of explosion.

It is known that accidents have occurred, when raising the temperatures above 200°C on various installations which do not comprise the means essential for doing this.

Without specifying the parameters, because this is not the object of this document, I can give some examples which will confirm the need to consider the preceding information with the most rigorous attention.

2006: In the North-East of France a recently installed furnace, anticipating the need to practice a treatment up to 230°C, is partially destroyed by a fire. The $10m^3$ load of wood is destroyed.

Cause: Sealing defect, penetration of oxygen in the furnace at high temperature + defect in operation of the safety measures. This furnace is repaired and returned to service a few months later.

2009: This same furnace is again partially destroyed by a new fire; same causes, apparently, as in 2006. It was repaired and returned to service at the end of 2009.

Between 1998 and 2008: Two furnaces of another manufacture are destroyed by explosions or fires.

Other types of furnaces intended for the treatment of wood at high temperature, which do not have the means necessary for avoiding the hazards of explosion or fire, are limited to treatments not exceeding 170 to 190°C.

Made at 25720 Beure, France, on March 10th, 2010.

Jean Laurençot
(signature)

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TRAITEMENT THERMIQUE DU BOIS A HAUTE TEMPERATURE

NIVEAU DE LA TEMPERATURE DE TRAITEMENT

Comme on a pu le constater, les résultats des tests de contrôle de qualité pratiqués depuis plus d'une décennie sur des échantillons de bois traités thermiquement, sous divers procédés, montrent que les changements apportés par ce type de traitement ont nettement modifié les principales propriétés qui pénalisent ce matériau à son état naturel, telles que la variation dimensionnelle et le manque de résistance au vieillissement qui perdurent lorsque le bois a seulement été soumis à un séchage traditionnel.

Si les principales et avantageuses améliorations, constatées sur le bois qui a subi un traitement thermique, sont apportées par la dégradation, sous température élevée, des hémicelluloses et autres substances extractibles qui rendent le bois hydrophile et putrescible à son état naturel ; il est également constaté que les meilleurs résultats sont obtenus avec les bois qui ont subi un traitement au dessus de 190°C ; surtout en ce qui concerne les essences de feuillus qui nécessitent des températures de traitement plus élevées que pour les résineux par exemple.

En effet, pour la plupart des essences les résultats optimums ont été obtenus sur des bois qui avaient subi un traitement à une température au moins égale à 230°C. C'est d'ailleurs à cette température que l'on observe, dans les fours qui permettent d'atteindre ce niveau de traitement, la plus forte concentration en rejet de gaz, de fumées et de goudrons issus de la dégradation des substances extractibles.

En conclusion : On peut donc considérer qu'un traitement thermique du bois ne peut pas être dit « à Haute Température » s'il est effectué à une température inférieure à 190°C.

Jean Laurençot
Le 10 Mars 2010

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HEAT TREATMENT OF WOOD AT HIGH TEMPERATURE LEVEL OF THE TREATMENT TEMPERATURE

As one could note, the results of quality control tests practiced for more than one decade on heat treated wood samples, under various processes, show that the changes brought about by this type of treatment clearly modified the principal properties which penalize this material in its natural state, such as dimensional variation and the lack of resistance to ageing which continue when the wood was only subjected to a traditional drying.

If the principal and advantageous improvements, noted on the wood which underwent a heat treatment, are brought about by degradation, under high temperature, of hemicelluloses and other extractable substances which make wood absorbent and putrescible in its natural state, it is also noted that the best results are obtained with wood which underwent a treatment above 190°C, especially with regard to the terpentines of leafy trees, which require treatment temperatures higher than for the coniferous trees, for example.

Indeed, for most terpentines, the optimum results were obtained on wood which had undergone a treatment at a temperature at least equal to 230°C. It is further at this temperature that one observes, in the furnaces which allow this level of treatment to be reached, the strongest concentration in the rejection of gas, smoke and tar resulting from the degradation of extractable substances.

In conclusion: One can thus consider that a heat treatment of wood cannot be called "at High Temperature" if it is carried out at a temperature lower than 190°C.

Jean Laurençot
March 10th, 2010
(signature)